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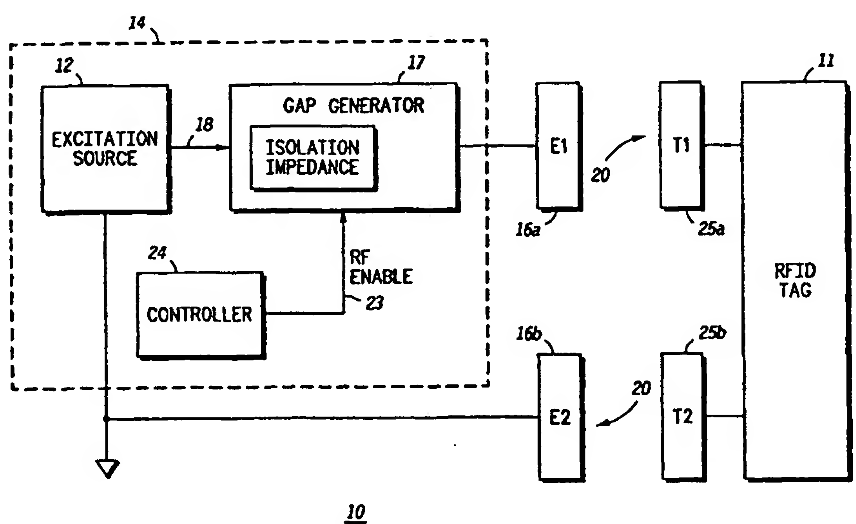

(57) Abstract

A contactless capacitive data transmission system utilizes a contactless capacitive data transmission circuit (10) and corresponding contactless capacitive data receiving circuit (70) that electrostatically communicates gap based information. The contactless capacitive data transmission circuit incorporates an excitation source (12) and an electrostatic data generator circuit (14) that is coupled to modulate an excitation signal from the excitation source for use of data for electrostatic transmission using gaps in transmission as a transmission format. The contactless capacitive data transmission circuit (10) includes a first and second electrostatic antenna element (16a and 16b) coupled to the electrostatic data generator circuit (14). The first and second electrostatic antenna elements (16a and 16b) are arranged for electrostatically transmitting the modulated data to a proximately located remotely powered electrostatic RFID tag (11) that includes the contactless capacitive data receiving circuit (70).

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A CONTACTLESS CAPACITIVE DATA TRANSMISSION SYSTEM AND METHOD

Cross-Reference to Related Applications

This is a continuation-in-part of commonly assigned prior U.S. patent application no. 09/031,848, filed February 27, 1998 by Victor Allen Vega et al., attorney docket no. IND10153, entitled, "Radio Frequency Identification Tag System Using Tags Arranged for Coupling to Ground."

Also, this is a continuation-in-part of commonly assigned prior U.S. patent application no. 09/041,480, filed March 12, 1998 by Victor Allen Vega et al., attorney docket no. IND10146, entitled, "Radio Frequency Identification Tag Arranged for Magnetically Storing Tag State Information."

Also, this is a continuation-in-part of commonly assigned prior U.S. patent application no. 09/045,357, filed March 20, 1998 by Victor Allen Vega, attorney docket no. IND10174, entitled, "Radio Frequency Identification Tag with a Programmable Circuit State."

Also, this application is related to commonly-assigned co-pending U.S. patent application no. 09/151,568, attorney docket no. IND10180 entitled, "Method and Apparatus for an Optimized Circuit for an Electrostatic Radio Frequency Identification Tag", filed on September 11, 1998 by Victor Allen Vega and John H. Rolin.

Field Of The Invention

The invention relates generally to contactless data transmission systems, such as those used to transmit data through a radio frequency identification (RFID) tag, and more particularly to contactless capacitive data transmission systems.

Background Of The Invention

Remotely powered electronic devices and related systems for programming such devices are well known. For example, one type of

remotely powered electronic device includes radio frequency identification tags (RFID) which are frequently used for personal identification and automated gate sentry applications protecting secured buildings or areas. Information stored in a radio frequency identification tag identifies the person seeking access to the secured building. Older systems require the person accessing the building to insert or swipe their identification tag into or through a reader for the system to read the information from the identification tag. A radio frequency identification (RFID) tag conveniently reads the information from the radio frequency identification tag at a small distance using radio frequency (RF) data transmission technology, eliminating the inserting or swiping operation.

The information stored on the RFID tag is typically programmed remotely using a programmer such as a base station that transmits an excitation signal to power up the radio frequency identification tag. The programmer then transmits information data to the RFID tag which in turn programs a storage device such as an electrically erasable programmable ROM (EEPROM), FeRAM or other memory that is located on a substrate of the RFID.

A typical technology for powering and programming a radio frequency identification tag is inductive coupling or a combination of inductive power coupling and capacitive data coupling. One communication system for RFID devices is disclosed in U.S. Patent No. 5,345,231 filed by Roland Koo et al. entitled "Contactless Inductive Data-Transmission System" issued September 6, 1994. With such systems, inductive coupling is used which requires incorporating a coil element into a radio frequency tag. The coil element is excited or energized by an excitation signal from the base station to provide power to the radio frequency identification tag circuitry. Once powered, the radio frequency identification tag, may use the tag coil to transmit and receive information between the radio frequency identification tag and the base station. Inductive RFID tags are relatively expensive, particularly for applications that may require a disposable radio frequency identification tag such as in an inventory management application, baggage handling application or other suitable application. Radio frequency identification tags relying on inductive coupling are also sensitive to orientation with the radio frequency identification tag with respect to the base station, since the field

created by the excitation signal must intersect the coil element at a substantially right angle for effective coupling. Furthermore, inductively coupled RFID tags are not flexible and can be damaged by printers when applying print on the tags. Moreover, the coils on the RFID tags can make manufacturing of RFID tags costly.

In writing to an RFID tag using known technologies, such as inductive coupling, integrated circuits are available, such as a standard read/write identification IC available from Temic North America Inc., Basking Ridge, New Jersey. With such systems, writing data onto the RFID integrated circuit (IC) is done based on interpreting an RF field having short gaps. The radio frequency pulses between two gaps encodes a 1 or 0 information. The first gap is typically a start gap which triggers the write mode on the RFID IC. Gaps are typically generated when electromagnetic energy damping is permanently enabled. This is designed to ease gap detection by a decoder circuit located in the RFID tag. The duration of the gap is usually 50 to 400 microseconds and the time between two gaps, for example, is normally 24 field clocks for a logic 0" and 56 field clocks for a logic 1". A problem arises since although such transmission methods maybe useful for electromagnetic based RFID tag systems, newer electrostatic RFID data based systems, such as those disclosed in the co-pending applications mentioned above, do not have defined transmission schemes. It is desirable to have a suitable transmission method for newer electrostatic based systems wherein expensive inductive tank coils and resonant capacitors are eliminated from an RFID tag. New electrostatic based contactless systems do not utilize a tank coil in the RFID tag to receive electromagnetic energy, but instead use electrostatic plates or other suitable antennas to send/receive electric fields. This substantially reduces costs and eases manufacturing constraints, making electrostatic base portable communication devices very desirable for many applications.

Consequently, there exists a need for an electrostatic RFID data transmission system that includes a contactless capacitive transmission circuit and corresponding contactless capacitive data receiving circuit to facilitate writing of information from a base station or to a remotely powered electronic identification tag.

Brief Description Of The Drawings

FIG. 1 is a block diagram depicting one embodiment of a capacitive data transmission circuit in accordance with the invention;

FIG. 2 is a graphic illustration of a electrostatic based write protocol generated by the circuit FIG. 1;

FIG. 3 is a block diagram of an alternative embodiment of a capacitive data transmission circuit in accordance with the invention;

FIG. 4 is another alternative embodiment of a contactless capacitive data transmission circuit in accordance with the invention;

FIG. 5 is one embodiment of a contactless capacitive data receiving circuit in accordance with the invention; and

FIG. 6 is alternative embodiment of a capacitive data transmission receiving circuit in accordance with the invention.

Detailed Description Of The Preferred Embodiments

Briefly, a contactless capacitive data transmission system utilizes a capacitive data transmission circuit and corresponding capacitive data receiving circuit that electrostatically communicates information. By contactless the applicant means information and/or data are communicated between the data transmission circuit and the data receiving circuit by method other than electrical connection. The contactless capacitive data transmission circuit incorporates an excitation source that is modulated (via suitable ASK, FSK or PSK techniques) for use in electrostatic data transmission. The contactless capacitive data transmission circuit includes a first and second electrostatic antenna element arranged for electrostatically transmitting the modulated data to a proximately located remotely powered electrostatic radio frequency identification tag that includes the contactless capacitive data receiving circuit.

In operation, the contactless capacitive data communication system receives electrostatically generated data from the contactless capacitive data transmission circuit and decodes the electrostatically received data to determine whether data received represents a logic "1" or a logic "0." If desired, the system detects a number of received cycles, frequency of received cycles, duration of electrostatically received data or phase of

electrostatically received data to determine whether the data received represents a data packet.

In one embodiment, the contactless capacitive data receiving circuit includes a first and second electrostatic antenna element that electrostatically receive data from the contactless capacitive data transmission circuit. The contactless capacitive data receiving circuit includes an electrostatic data decoder coupled to the first and/or second antenna elements, that decodes electrostatically received data to determine whether data received represents a logic "1" or logic "0". In one embodiment, the contactless capacitive data transmission system utilizes demodulated interrupts in RF fields as short gaps in accordance with a predefined gap scheme. The decoder detects a field gap in electrostatically received data, detects data that is to be programmed into an integrated circuit located on a remotely powered electronic identification tag, and determines valid cycles within the electrostatically received data. If desired, one of the electrostatic antenna elements may be at ground potential to create a monopole receiver.

FIG. 1 illustrates one embodiment of a contactless capacitive data transmission circuit 10 that capacitively transmits data to a contactless portable communication device, such as an electrostatic radio frequency identification (RFID) tag 11. The contactless capacitive data transmission circuit 10 includes an electrostatic data generator circuit 14 coupled to a first and second electrostatic antenna element 16a and 16b, such as electrostatic plates. The electrostatic data generator circuit 14 includes an excitation source 12, a gap generator circuit 17 and a controller 24. The contactless capacitive data transmission circuit 10 can be used with lower cost electrostatic RFID tag systems or other suitable remotely powered devices. The contactless capacitive data transmission circuit 10 may be located, for example, on a base station. The RFID tag 11 includes a first electrostatic antenna element 25a (T1) and a second electrostatic antenna element 25b (T2).

The excitation source 12 may be a piezoelectric crystal based excitation source, an inductive excitation source or other suitable excitation source, and oscillates about a frequency of about 125 kilohertz, or any other suitable frequency. The excitation source 12 generates an excitation signal 18 which is modulated by the electrostatic data generator circuit 14. The

electrostatic data generator circuit 14 modulates the excitation signal as data 20 for electrostatic transmission. The electrostatic data generator circuit 14 in this embodiment, is an amplitude modulator that uses the gap generator and controller 24 to periodically modulate the excitation signal 18 peak to peak voltage level to generate data bits and gaps between data bits. The controller 24, by modulation of the excitation signal 18, forms electrostatically transmitted data packets between the contactless capacitive data transmission circuit 10 and the electrostatic RFID tag 11.

In this embodiment, the excitation signal 18 is controlled to periodically modulate the excitation signal peak to peak voltage levels between about 100% to 0%. However it will be recognized that any suitable amplitude modulation levels may also be used. The controller 24 turns the gap generator circuit 17 on and off to generate data in a data format including a start gap followed by alternating data fields and field gaps as write data for a programmable integrated circuit located on the remotely powered electrostatic RFID tag 11. A field gap represents an interval between information detected to be a data bit. It will be recognized that the gap generator circuit 17 may be any suitable type of dampening device or switching device to modify the excitation signal to facilitate a gap between data bits.

In operation, the isolation impedance isolates the gap generator circuit 17 from the excitation source 12 so that the excitation source 12 is not unduly loaded when the gap generator circuit 17 is operational. The controller 24, which may be any suitable logic, generates a radio frequency enable signal 23 to enable and disable the gap generator circuit 17. The gap generator circuit 17 acts as a switch to open the circuit to prevent a signal from being output or may act as a dampening device to shunt the excitation signal to generate gaps in the excitation signal 18 to create a data packet.

Referring to FIG. 2, the write data format 40 for a data packet is shown. The write data format 40, as generated by the contactless capacitive data transmission circuit 10, includes an initial undampened RF field 41 and start gap 42 followed by a number of undampened excitation cycles 44a, 44b, separated by field gaps 45. By way of example, the undampened clock cycles are detected by the electrostatic RFID tag 11 to be data representing a logic "0". The initial undampened RF field 41 "primes" the integrated circuit to allow the on-board power circuit to charge up. Signal 46a and 46b for

example have duration periods longer than those of 44a and 44b and include more cycles of the excitation signal 18 and are interpreted to represent a logic "1". It will be recognized, that the logic may be reversed if desired.

Referring back to FIG. 1, the contactless capacitive data transmission circuit 10 has the pair of antenna plates E1 and E2 that operate as a balanced out of phase pair. It will be recognized that arrays of such antenna plates may also be used, however, for simplicity sake, the description will be limited to two exemplary antenna plates. Alternatively for example, wire antenna electrostatic elements or comb like structures may be employed instead antenna plates. In addition, one of the antenna plates may be removed or coupled to ground to form a monopole arrangement.

If desired, the contactless capacitive data transmission circuit 10 may include a reader portion (not shown) which may include a single electrostatic reader antenna plate connected to a receiver which provides input signals to a detector. An I/O processor may receive signals from the detector to convert the signals for evaluation by a processor to confirm, for example, that data written to the electrostatic RFID tag 11 was successful. The reader may also be used for example to read identification data stored therein with the contactless capacitive transmission circuit incorporated as part of a base station.

FIG. 3 shows an alternative embodiment of a contactless capacitive data transmission circuit 50 that employs frequency modulation instead of amplitude modulation. In this embodiment, an excitation source, such as a sinusoidal source 52, outputs an excitation signal to a multiplier 54 which then receives enable signals 55. A voltage controlled oscillator (VCO) 56 receives the output from the multiplier and receives frequency control signal 57 to control the frequency of the signal from the VCO 56. Variable frequency output signal 58 serves as input to the amplifier 59. The amplifier 59 then outputs the variable frequency output signal 58 to the transformer 26. The enable signal 55 may be a zero resulting in no output from the multiplier 54. If desired, the contactless capacitive data transmission circuit 50 may be used as an amplitude modulator. It will also be recognized that phase modulation may also be used.

By way of further example, FIG. 4 represents another implementation of a contactless capacitive data transmission circuit configured as a bipole

amplitude modulation circuit that employs a switching transistor 60 as the gap generator. As such, an excitation drive signal 61 generated by a controller, may be a simple digital pulse to allow for a complete dampening of the excitation signal 18. Hence, the digital input data to the transistor 60 serves to modify the amplitude of the excitation signal 18 by turning the transistor on for a suitable time to shunt the excitation signal, or by changing the amplitude by varying the duty cycle to the base of the transistor. The circuit includes a dampening resistor 64 (optional) and a resonant capacitor 66 in parallel across the secondary coil. The parallel connected capacitor is selected to have the signal resonate at the frequency of the excitation drive signal 61. The electrostatic based data provided to the electrostatic antenna 16a via the top terminal of the secondary coil is balanced and 180 degrees out of phase with the signal provided via the bottom terminal of the secondary coil 16b. The electrostatic antennas produce electric fields, indicated by the arrows, which are used to power up and write to the electrostatic based RFID tag 11. It will be appreciated by those of ordinary skill in the art that the desired voltage levels of the electric field may depend upon factors such as the distance from which the transmission circuit is to power up the device. Additionally, desired voltage levels may, for example, depend upon frequency emission requirements for the country in which the transmission circuit will be used.

FIG. 5 illustrates one embodiment of a contactless capacitive data receiving circuit 70 that has at least a first and second antenna element 25a (T1) and 25b (T2) that electrostatically receive the data 20 such as in write data format 40 (FIG. 2) from the contactless capacitive data transmission circuit. The contactless capacitive data receiving circuit 70 includes an electrostatic data decoder 71 which is coupled to the first and second electrostatic antenna element 25a and/or 25b. The electrostatic data decoder decodes electrostatically received data 20 to determine whether the data received represents a logic "1" or a logic "0".

The electrostatic data decoder 71 includes a clock extraction circuit 72, a level detection circuit 74, a gap detector circuit 76, a cycle counter 78 and a data interpreter 80. The clock extraction circuit 72 receives the data 20 and serves as an analog to digital converter to generate a digital clock signal 82 based on each cycle detected in the received signal. The level detection

circuit 74 includes a threshold based voltage level detector that also receives the data 20 and outputs a digital signal 84 representing detected cycles that are above the threshold. The level detection circuit 74 determines valid cycles within the electrostatically received data 20. The gap detector circuit 76 counts the clock signal 82 to determine whether a field gap or start gap has been detected. If a gap has been detected, the gap detector circuit 76 generates a reset signal 86. The RF cycle counter 78 resets when it detects the reset signal 86. The data interpreter 80 interprets whether a previous group of cycles is a logic "1" or logic "0".

If no reset signal is detected, the RF cycle counter 78 counts the number of cycles between gaps and outputs count data 88 to the data interpreter 80. The count data is used to determine whether a group of cycles constitutes a logic "1" or logic "0". Hence when the data is write data, the cycle counter detects data that is to be programmed into the integrated circuit located on the RFID tag. The data interpreter 80 is a comparator which detects the duration of each undampened interval between field gaps to determine whether the information is a logic "1" or a logic "0". For example, if the count data 88 is within an acceptable range, such as equal to 56 for example, the data interpreter 80 may determine that the information represents a logic "1". If the time between two gaps is 24 clocks, for example, the data interpreter 80 may determine that the data is a logic "0". Also if desired, the circuitry previously described may be basically duplicated for the other electrostatic antenna element 25b. The information is then output to a controller (not shown) which may be for example a counter which determines whether the data represents a data packet and also determines the content of the data packet. The controller may be any suitable logic and may serve as a storage register and data packet validator to determine if a proper format is used. For example, during a write command, the controller may determine whether data represents a proper operational code (op code) data, proper number of bits to be stored as memory data, a lock bit and memory address data and configuration mode data. Configuration mode data may be for example data representing whether the integrated circuit should be in a read mode, write mode, whether it is for an RFID or other device, the data rate at which data is to be communicated, and other types of mode data,

if desired. Also, it will be recognized that the above decoder may also be implemented using digital logic if desired.

The contactless capacitive data transmission circuit in combination with the contactless capacitive data receiving circuit form a contactless capacitive data transmission system. As such, the above identified embodiments can be used for contactlessly writing electrostatically coupled data from a base station to a tag to allow a simple fabrication of an RFID tag decoder for example. Other advantages will also be evident to those of ordinary skill in the art.

It should be understood that the implementation of other variations and modifications of the invention in its various aspects will be apparent to those of ordinary skill in the art, and that the invention is not limited by the specific embodiments described. For example, it will be recognized that any suitable modulation scheme may be employed, such as FSK, PSK or other suitable technique. Also the decoders of FIGS. 5 and 6 can be coupled to only one antenna element if desired so that a monopole configuration may be used, or a combination of each type of decoder may be used. In addition, it may be desirable to program the RFID during manufacturing by using a contact based programmer. It is therefore contemplated to cover by the present invention, any and all modifications, variations, or equivalents that fall within the spirit and scope of the basic underlying principles disclosed and claimed herein.

What Is claimed Is:

CLAIMS

1. A capacitive data transmission circuit comprising:

an excitation source that generates an excitation signal;

an electrostatic data generator circuit operatively coupled to modulate the excitation signal as data for electrostatic transmission; and

at least a first antenna element operatively coupled to the electrostatic data generator circuit,

the at least first antenna element arranged for electrostatically transmitting the data to a proximately located remotely powered radio frequency identification (RFID) tag.

2. The capacitive data transmission circuit of claim 1 wherein the electrostatic data generator circuit modulates by at least one of amplitude modulation, frequency modulation and phase modulation to form electrostatically transmitted data packets.

3. The capacitive data transmission circuit of claim 2 wherein the electrostatic data generator circuit includes an amplitude modulator having a gap generator circuit controlled to periodically modulate the excitation signal to generate data bits and gaps between data bits.

4. The capacitive data transmission circuit of claim 2 wherein the electrostatic data generator circuit includes an amplitude modulator to periodically modulate the excitation signal between about 100%-0% to generate data bits and gaps between data bits wherein the data bits represent at least one of op code data and memory address data.

5. The capacitive data transmission circuit of claim 1 wherein the electrostatic data generator circuit includes a frequency modulator.

6. The capacitive data transmission circuit of claim 1 wherein the electrostatic data generator circuit generates the data in a format including an

initial undampened RF field, a start gap followed by data fields and field gaps as write data for a programmable integrated circuit located on the remotely powered RFID tag.

7. The capacitive data transmission circuit of claim 6 wherein the data fields include data representing at least one of: operational code data, memory address, memory data, a lock bit and configuration mode data.

8. The capacitive data transmission circuit of claim 1 wherein the at least first antenna element is an electrostatic plate.

9. The capacitive data transmission circuit of claim 1 including a second electrostatic antenna element.

10. A capacitive data receiving circuit comprising:

at least a first and second antenna element that electrostatically receive data from a capacitive data transmission circuit; and

an electrostatic data decoder operatively coupled to at least one of the first and second antenna elements, that decodes electrostatically received data to determine whether data received represents a logic "1" or a logic "0."

11. The capacitive data receiving circuit of claim 10 wherein the electrostatic data decoder includes a gap detector circuit that detects a gap in electrostatically received data to facilitate a determination of whether the data received represents a logic "1" or a logic "0.

12. The capacitive data receiving circuit of claim 10 wherein the electrostatic data decoder is located on a remotely powered electrostatic RFID tag and includes:

a gap detector operatively coupled to receive the electrostatically received data;

a cycle counter operatively coupled to receive the electrostatically received data; and

a level detection circuit, operatively coupled to the clock counter,

wherein the gap detector detects a start gap and field gaps, the cycle counter detects data that is to be programmed into an integrated circuit located on the remotely powered RFID tag and wherein the level detection circuit determines valid cycles within the electrostatically received data.

13. The capacitive data receiving circuit of claim 10 wherein the electrostatic data decoder determines whether the data includes data representing at least one of: operational code data, memory address, memory data and configuration mode data.

14. A capacitive data transmission system comprising:

(a) a capacitive data transmission circuit including,

an excitation source that generates an excitation signal;

an electrostatic data generator circuit operatively coupled to modulate the excitation signal as data for electrostatic transmission; and

at least a first antenna element operatively coupled to the electrostatic data generator circuit;

the first and second antenna elements arranged for electrostatically transmitting the data to a proximately located remotely powered electrostatic radio frequency identification (RFID) tag, and

(b) a capacitive data receiving circuit including,

at least a first and second antenna element that electrostatically receives data from the capacitive data transmission circuit; and

an electrostatic data decoder operatively coupled to the first and second antenna elements, that decodes electrostatically received data to determine whether data received represents a logic "1" or a logic "0."

15. The capacitive data transmission system of claim 14 wherein the electrostatic data generator circuit modulates by at least one of amplitude modulation, frequency modulation and phase modulation to form electrostatically transmitted data packets.

16. The capacitive data transmission system of claim 15 wherein the electrostatic data generator circuit includes an amplitude modulator controlled

to periodically modulate the excitation signal to generate data bits and gaps between data bits.

17. The capacitive data transmission system of claim 15 wherein the electrostatic data generator circuit includes an amplitude modulator a gap generator circuit controlled to periodically modulate the excitation signal between about 100%-0% to generate data bits and gaps between data bits.

18. The capacitive data transmission system of claim 14 wherein the electrostatic data generator circuit generates the data in a format including an initial undampened RF field, a start gap followed by data fields and field gaps as write data for a programmable integrated circuit located on the remotely powered RFID tag.

19. The capacitive data transmission system of claim 14 wherein the first and second antenna elements are capacitive plates.

20. The capacitive data transmission system of claim 14 wherein the electrostatic data decoder includes a cycle counter that detects electrostatically received data to determine whether the data received represents a logic "1" or a logic "0".

21. The capacitive data transmission system of claim 14 wherein the electrostatic data decoder is located on the remotely powered RFID tag and includes:

a gap detector operatively coupled to receive the electrostatically received data;

a cycle counter operatively coupled to receive the electrostatically received data; and

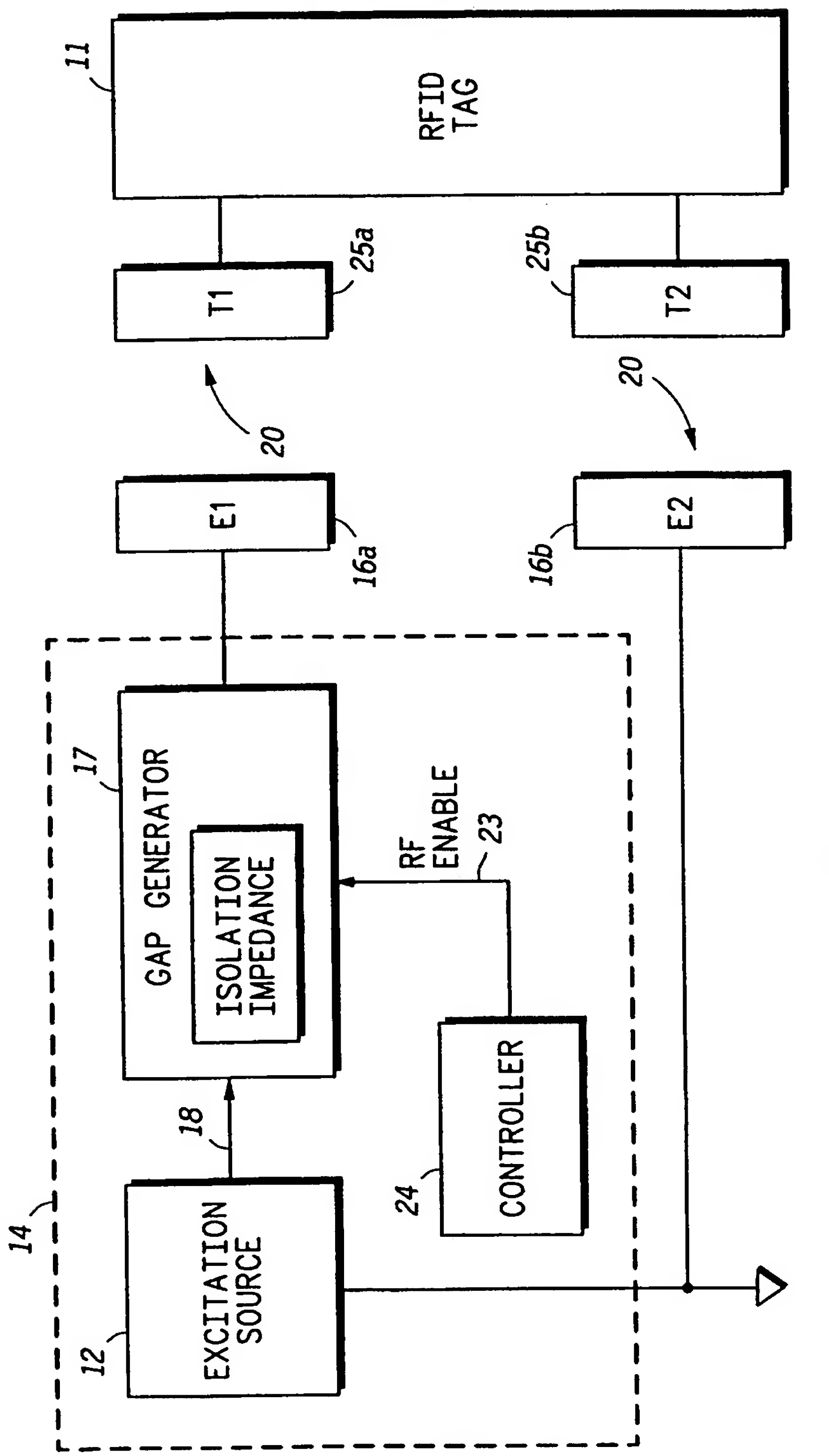
a level detection circuit, operatively coupled to the cycle counter, wherein the gap detector detects a field gap, the cycle counter detects data that is to be programmed into an integrated circuit located on the remotely powered RFID tag and wherein the level detection circuit determines valid cycles within the electrostatically received data.

22. The capacitive data transmission system of claim 14 including a second capacitive antenna element operatively coupled to the electrostatic data generator.

23. The capacitive data transmission system of claim 14 wherein the capacitive data transmission circuit is contactless.

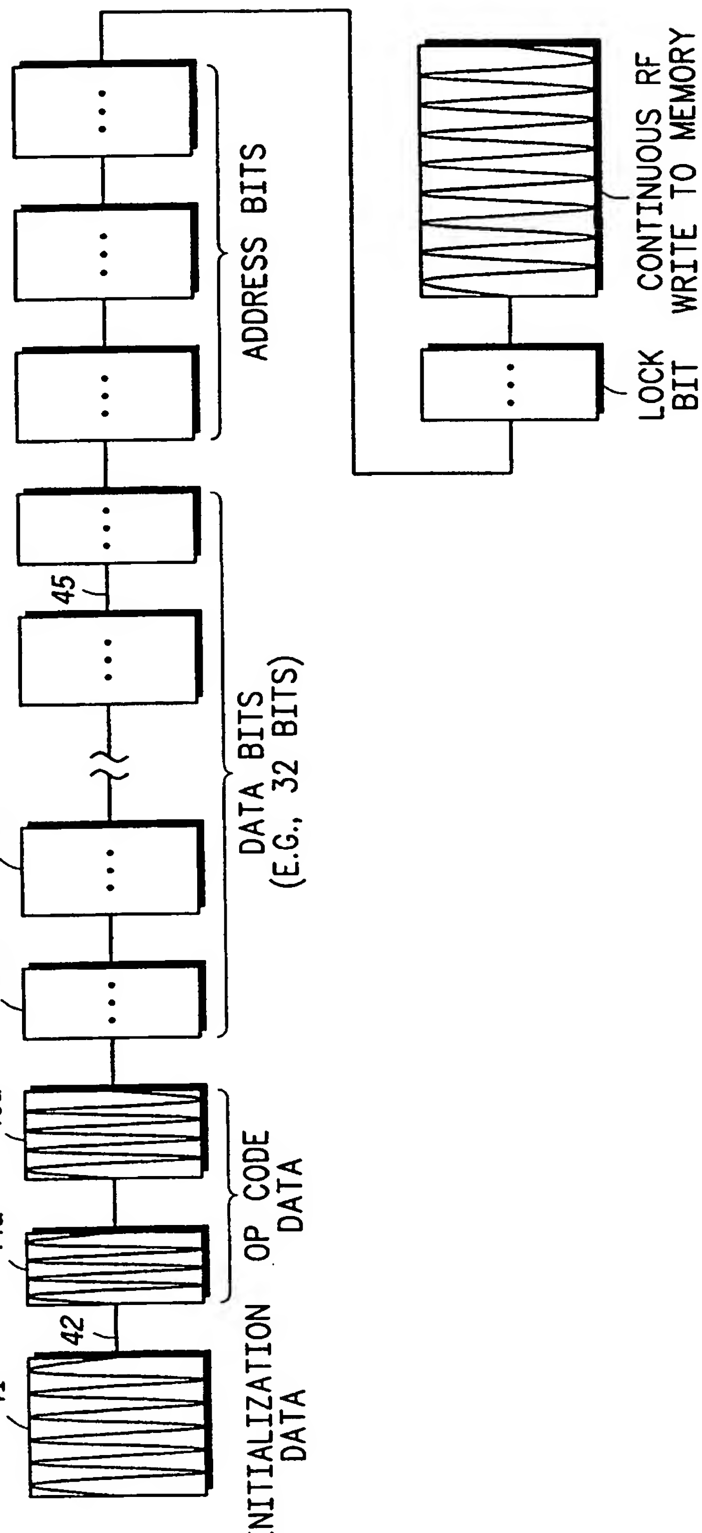
24. A capacitive data communication method comprising the steps of:
receiving electrostatically generated data from a contactless capacitive data transmission circuit; and
decoding the electrostatically received data to determine whether data received represents a logic "1" or a logic "0."

25. The capacitive data communication method of claim 24 including the steps of:
detecting a field gap,
detecting data that is to be programmed into an integrated circuit located on a remotely powered electronic identification tag, and
determining valid cycles within the electrostatically received data.


11
RFID TAG
T1
25a
T2
25b
20
20
E1
16a
E2
16b
14
17
GAP GENERATOR
ISOLATION IMPEDANCE
RF ENABLE
23
18
24
CONTROLLER
12
EXCITATION SOURCE

10

FIG.1


41
42
INITIALIZATION DATA
44a
46a
OP CODE DATA
44b
46b
45
DATA BITS (E.G., 32 BITS)
ADDRESS BITS
LOCK BIT
CONTINUOUS RF WRITE TO MEMORY

40

FIG.2

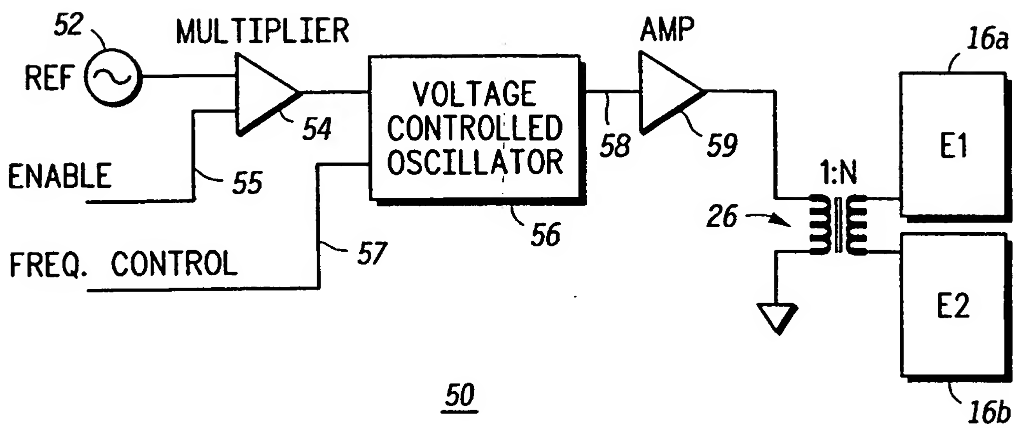

52
REF
MULTIPLIER
54
ENABLE
55
FREQ. CONTROL
57
VOLTAGE CONTROLLED OSCILLATOR
56
58
AMP
59
1:N
26
16a
E1
E2
16b
50

FIG.3

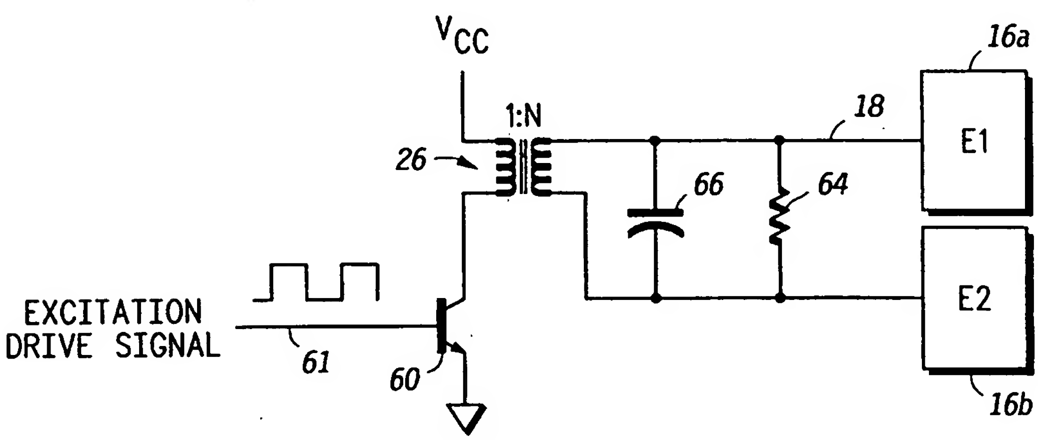

VCC
1:N
26
18
16a
E1
66
64
EXCITATION DRIVE SIGNAL
61
60
E2
16b

FIG.4

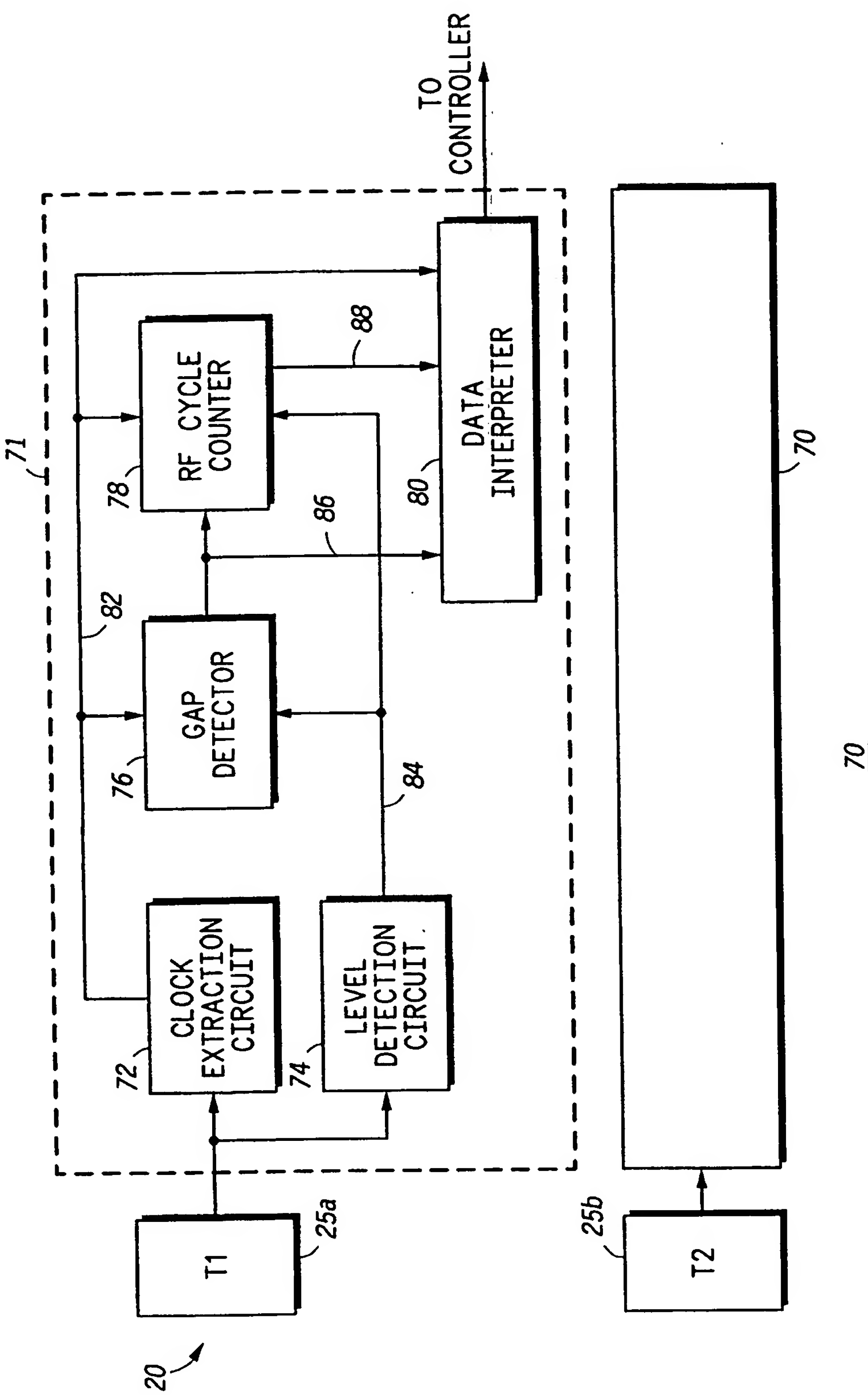

TO CONTROLLER
71
RF CYCLE COUNTER
78
88
DATA INTERPRETER
80
86
82
GAP DETECTOR
76
84
CLOCK EXTRACTION CIRCUIT
72
LEVEL DETECTION CIRCUIT
74
T1
25a
T2
25b
20
70
70

FIG.5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/20798

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :GO6K 7/00
US CL :340/572.1, 572.4, 825.34
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 340/572.1, 572.4, 825.31, 825.34, 825.54

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- A	US 5,382,952 A (MILLER) 17 January 1995 (17/01/95), see figure 1 and column 3, lines 3-48.	24 --- 1-23, 25
A	US 5,500,651 A (SCHUERMANN) 19 March 1996 (19/03/96), see especially figure 2.	1-25

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

28 OCTOBER 1999

Date of mailing of the international search report

09 NOV 1999

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